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# NOISE INDUCED HEARING LOSS AND AUDITORY LOCALIZATION

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**Introduction** Many studies have been conducted on the ability of normal hearing listeners to judge the locations of various sounds. A few researchers have explored the effects of noise-induced hearing loss on auditory localization acuity (Noble, Byrne and Lepage, 1994; Smith-Olinde, Koehnke and Besing, 1998; and Lorenzi, Gatehouse and Lever, 1999). These researchers have shown that the use of higher frequency energy in the signal is reduced by high-frequency hearing loss. Elevation acuity is more affected by high-frequency hearing loss than azimuth acuity, which is dominated by interaural time difference cues. Many factors, including the temporal and spectral characteristics of the sound source, the listening environment, the types of interfering sound sources, and the listener's auditory system, affect localization acuity. Two of those factors, the effects of noise-induced hearing loss and head motion cues, are reported in the current study.

**Methods** The experiments were conducted in the auditory localization facility at Wright-Patterson Air Force Base. The facility includes a 2.13-meter-diameter geodesic sphere with 272 loudspeakers housed inside an anechoic chamber. Sounds were generated with Tucker Davis Technology equipment and controlled by a Pentium based personal computer.

Subjects: Six subjects ranging from 18 to 50 years of age were recruited from the general population for these experiments. The listeners' hearing profiles are shown in the table below.

| | Test Frequency (Hz) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 500 | | 1000 | | 2000 | | 3150 | | 4000 | | 6300 | | 8000 | |
| Subject # | R | L | R | L | R | L | R | L | R | L | R | L | R | L |
| 1 | -5 | -5 | -5 | 0 | 0 | 5 | 5 | 5 | 5 | 10 | 5 | 5 | 0 | 10 |
| 2 | 0 | 10 | -10 | 0 | 15 | 15 | 25 | 15 | 15 | 10 | -10 | 35 | 0 | 65 |
| 3 | -5 | 0 | 0 | 0 | -5 | -10 | 10 | -10 | 40 | -10 | 15 | 0 | 0 | -10 |
| 4 | 25 | 25 | 30 | 25 | 15 | 20 | 25 | 35 | 25 | 45 | 25 | 40 | 35 | 20 |
| 5 | 10 | 10 | 15 | 20 | 30 | 30 | 50 | 45 | 55 | 40 | 20 | 10 | 15 | 60 |
| 6 | 10 | 60 | 15 | 65 | 10 | 40 | 10 | 65 | 10 | 70 | 10 | 70 | 0 | 75 |

Stimuli: Pink noise with a bandwidth of 200 to 13 kHz was used as the target stimulus. The noise stimulus was presented at 75 dB SPL and at three durations of 250 ms, one second, and as a continuous sound until localized. The spectrum was corrected for the frequency response of the loudspeakers. One hundred seventy-two locations were selected for the noise stimuli.

Procedure: Localization acuity was measured using a pointing response method called the God's-Eye Localization Procedure (GELP) (Gilkey, Good, Ericson, Brinkman, and Stewart, 1995). In this technique, the subject responded after each stimulus presentation by positioning the tip of an electro-magnetic stylus at a point on the surface of a 20-cm plastic spherical model of auditory space to indicate the perceived direction of the auditory image. Localization acuity was measured with restricted head motion by a chin rest and with unrestricted motion.

**Results** The main effect of hearing loss had a large effect on localization acuity and front-to-back reversal rates. Mild levels of noise-induced hearing loss mostly affected elevation acuity, especially at very high and low angles. The moderately hearing impaired subjects showed degraded acuity in azimuth as well as in elevation.

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Head motion improved localization acuity and greatly reduced front-to-back reversal rates for the normal and mildly impaired subjects (1-4). However, the moderately hearing impaired subjects (5 and 6) had lower acuity and higher front-to-back reversal rates for the free head motion condition than for the restricted head motion condition. These data are shown below in Figure 1 (a) and (b).

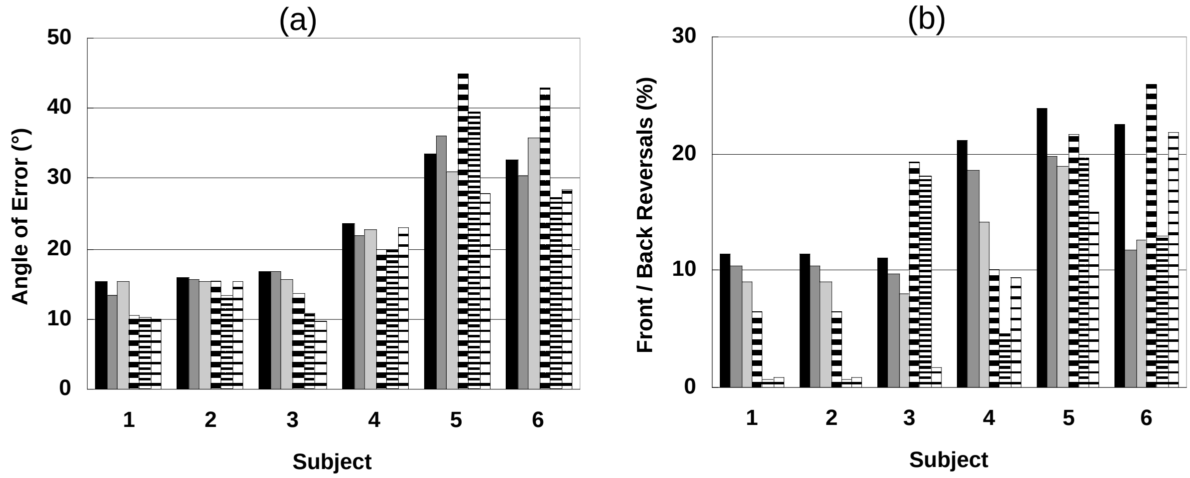


Figure 1: Angle of error (a) and percent of front-to-back reversals versus subject (b), chin rest (solid) and unrestricted (dashed) for 0.25S (dark), 1S (gray) and continuous (light) durations.

**Discussion** Lower acuity and higher reversal rates typically occur when the sound source is under-specified in spectral complexity and temporal envelope patterns. The presence of interfering sounds tends to confuse the identities of the target and maskers. These problems are expected to be further complicated due to reduced frequency and spatial acuity of hearing impaired listeners. Further research is needed to address these issues and to determine the expected utility of spatial auditory displays by hearing impaired listeners.

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**Keywords** Auditory localization, noise induced hearing loss, head motion.

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